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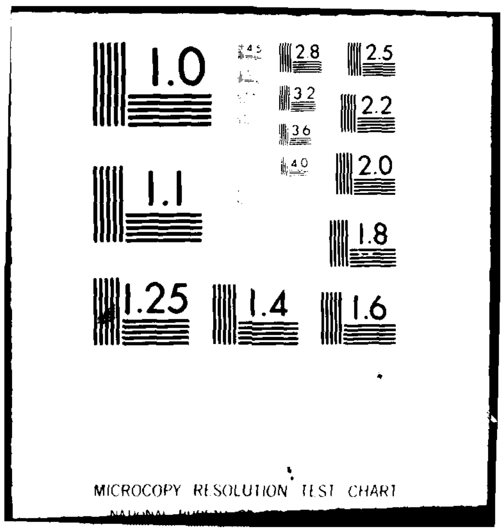
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NEAR INFRARED SPECTROMETRIC AIRGLOW MEASUREMENTS DURING THE TOTAL SOLAR ECLIPSE OF 26 FEBRUARY 1979

by
W. R. Pendleton, Jr.

15 January 1981
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Airglow	Radometric Data
Twilight Transition	OH Meinel Emissions
Nightglow	O_2 IR Atmospheric Emissions

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

Spectrometric airglow measurements during the solar eclipse of 26 February 1979 have yielded first-of-a-kind residual airglow spectra during the total phase of the eclipse. The temporal variations of the 02 infrared atmospheric features and the He multiplet at 1.083 microns are consistent with current [illegible]itation/emission models; however, the OH Meinel emission levels decreased

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SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered) almost monotonically by totality, in contrast with expectations based on most code predictions. Twilight transition, nightglow, and auroral data were also acquired to characterize airglow conditions during the general timeframe of the eclipse. The twilight-transition results compare favorably with similar earlier measurement by other investigators.

19. HeI λ10,830A Emission
(cont) Auroral Measurements

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The sizeable contribution of Jeff Blakeley to the success of the expedition is gratefully acknowledged. The most beneficial cooperation and assistance provided by Mr. Alvin Frey of the Stormer Lake Fellowship Center is also acknowledged with gratitude. The many and varied contributions of Brent Bartschi are also acknowledged.

INTRODUCTION

The total eclipse of the sun which occurred on 26 February 1979 was observable from center-line and near-center-line locations in the northwestern United States, southern Saskatchewan and Manitoba, northwestern Ontario, and other more northerly points. This eclipse was the last total solar eclipse observable from North America in this century. It afforded atmospheric scientists in the U.S. and Canada a unique opportunity to study the interrelationship of many factors which influence the chemical, physical, and electrical structure of the middle atmosphere of the earth.

An eclipse provides a day-"night"-day transition on the time scale of a few minutes. This time scale is sufficiently long for meaningful studies of the fast ion chemistry and of the neutral species with short photochemical/chemical lifetimes. However, the duration of the event is short enough to ensure that transport phenomena can be ignored and that the bulk properties of the neutral atmosphere vary in a regular and predictable manner.

A fairly extensive coordinated Eclipse '79 Field Program was mounted by U.S. Agencies (Army, Air Force, NASA) in cooperation with the National Research Council of Canada. A major objective of this DOD-sponsored Solar Eclipse Program was to obtain sets of complementary measurements in the D region of the lower ionosphere (60-90 km) in order to provide "benchmarks" for testing sophisticated D-region predictive computer codes, such as the DAIRCHEM code of the U.S. Army's Atmospheric Sciences Laboratory. The field program involved the launching of twenty (20) small sounding rockets and fifteen (15) large rockets during the time frame 2/19/79 - 2/27/79, with the majority of the launches (19) between first and fourth contacts on the day of the eclipse. In addition to these rocket-based measurements, several atmospheric properties were monitored from the ground prior to, during, and after the eclipse.

As part of the DOD 1979 Solar Eclipse Program, Utah State University was funded through AFOSR to conduct ground-based near-infrared airglow measurements in support of (and complementary to) the AFGL rocket-based totality measurements of selected IR airglow emissions. The proposed program included interferometric and radiometric measurements of the near-infrared airglow in the twilight and night, as well as during the total phase of the eclipse.

In pre-expedition planning, the ground-based IR measurements at totality were deemed "relatively high risk". The basis for this evaluation was climatographic records which clearly revealed little better than a 50/50 chance for good observing conditions. This concern was borne out when heavy cloud cover prevailed above the observing site throughout the period of the eclipse. However, in spite of the poor conditions, first-of-a-kind time-resolved near-IR (0.8 - 1.65 μm) residual airglow spectra were obtained during the total phase of the eclipse. These spectra were degraded by the "diffusing screen" (cloud layers) between the instrument and the high-altitude emitting regions, but the airglow features were clearly discernable on the background of scattered solar radiation.

Excellent twilight-transition and nightglow data were acquired the evening and night of 26 February 1979. These data provide a useful "benchmark" for airglow conditions several hours after the eclipse. In addition, useful twilight transition and nightglow data were recorded on 2/23/79 and 2/24/79. Cloud cover severely degraded the data taken at other times.

The primary purpose of this report is to document the progress and significant accomplishments under Grant No. AFOSR-79-0040. An attempt has been made to include enough detail relating to the field program, the data base, the analysis, and comparisons to permit an evaluation of performance, while avoiding finer details which might obscure the primary objectives. The data presented in the report reflect representative samples, except for the measurements at totality. The magnitude of the total data base from the mission prevents convenient inclusion in this report. However, these data are stored in the USU/EDL Data Archives for future access and are available to other qualified "eclipse experimenters" upon request.

The principal results documented herein have been presented at professional meetings and at the 1979 Solar Eclipse Workshop, which was convened at New Mexico State University on 26-27 September 1979. Two manuscripts are currently being prepared for submission to appropriate technical journals.

SUMMARY OF RESEARCH OBJECTIVES

Primary Objectives

1. Obtain time-resolved residual dayglow spectra in the 0.8 - 1.7 μm region during the total phase of the eclipse. Also, determine absolute emission levels for the OH Meinel and O_2 IR atmospheric emissions by means of an absolutely calibrated dual-channel radiometer.
2. Obtain twilight-transition and nightglow measurements similar to (1) both prior to and after the eclipse.
3. Compare the data, to the extent possible within funding constraints, with current photochemical models and with rocket-based near-IR measurements.

Secondary Objective

Make selected spatial and spectral measurements of the sky brightness to provide data for testing the radiative-transfer problem as it applies to the eclipse geometry.

DESCRIPTION OF FIELD PROGRAM

Preparations for Expedition

W.R. Pendleton and B.Y. Bartschi traveled to Canada on 18 September 1978 to conduct a survey for the purpose of locating a suitable near-center-line position for the USU Mobile Observatory. The near-center-line constraint proved formidable and initially appeared to rule out positioning the observatory in the vicinity of the rocket launch sites.

After considerable investigation at Red Lake, Ontario, the designated site for the rocket program, it was discovered that a low-maintenance road permitted access to points <50 mi from the center line of the eclipse. The most favorable site was selected, and tentative local arrangements were made to use the site.

Consideration was also given to Riverton, Manitoba. The Riverton site was located on the center line of the eclipse. The site survey revealed very favorable local conditions for operating the observatory. However, in the final analysis, it was decided to locate the observatory at the remote site north of Red Lake. This decision was based primarily on considerations relating to "proximity" and "program coordination".

Preparations for the expedition to Canada were made during the period 12/1/78 and 2/10/79. Power sources for remote operation were acquired and interfaced with the mobile observatory. The instrumentation aboard the observatory was reconfigured for the mission, and instrument performance was checked using the portable power sources. In addition, the "logistics" for the mission were formulated and appropriate actions were taken.

Expedition

The mobile observatory was on site by 2/21/79, several days behind schedule. A significant delay was encountered in transit from Logan, Utah to

Red Lake, Ontario. Blizzard conditions and extreme temperatures, which resulted in severe problems with fuel-system icing, prevailed through much of Nebraska and Iowa and resulted in the loss of about three days. Additional time was lost in Red Lake, Ontario where the preparations for the trip to the remote site were completed. Arrangements were made to transport cryogens and tanks of propane to the site. In addition preparations were made to remain at the site for an extended period in the event of inclement weather.

Approximately one day was required to complete the set-up operation at the remote site. Instrumentation checks were completed on 2/23/79, and data were acquired during the evening and the night. The observatory was operated at the remote site during the period 2/23/79 - 2/26/79. The original schedule called for measurements through 3/2/79. However, the timely clearing in the early evening on 2/26/79 resulted in the acquisition of excellent twilight-transition and nightglow data. This factor coupled with the predictions for cloudy to partly-cloudy conditions resulted in the decision to terminate observations.

Observational Techniques

The complement of instruments aboard the mobile observatory is summarized in Table 1. The data-logging system used during the expedition is illustrated in the block diagram of Figure 1. The "prime instruments" for the eclipse expedition were the infrared field-widened interferometer (IRFWI) and the dual-channel near-infrared radiometer (NIR RAD).

The IRFWI has been described in detail in the lieterature (Haycock and Baker, 1974). Briefly, this instrument is an extension of the conventional Michelson interferometer. Two compensating prisms are used in such a way that incident light rays that are as oblique as 6° can be accepted by the interferometer even when it is driven to "high resolution" (Despain et al., 1970). The prisms are back-surface mirrored to serve as the end mirrors of

Table 1. Complement of instruments in the USU Mobile Observatory for the 1979 Solar Eclipse Expedition.

Instruments		Wavelength Coverage Center Wavelength	Spatial Characteristics	Temporal Characteristics
<u>INTERFEROMETERS</u>				
*IRFWI		0.8 μm to 1.65 μm	12° FOV, Manually Pointed	13 seconds/scan (min)
<u>RADIOMETERS</u>				
*NIR RAD (dual channel)		1.27 μm & 1.70 μm	9° FOV, Manually Pointed	30 second TC (typical)
<u>PHOTOMETERS</u>				
*RFP	actual coverage	0.38 μm to 0.87 μm	5° FOV, Manually Pointed	10 second filter scan
*MSP	depends on filters	0.38 μm to 0.87 μm	2° FOV, Continuous Scan	13 second scan
*DPC	selected	0.38 μm to 0.87 μm	5° FOV, Co-aligned with NIR RAD	N/A

*<u>KEY</u>: IRFWI = infrared field-widened interferometer
NIR RAD = near-infrared radiometer
RFP = rocking filter photometer
MSP = meridian scanning photometer
DPC = digital photon counters

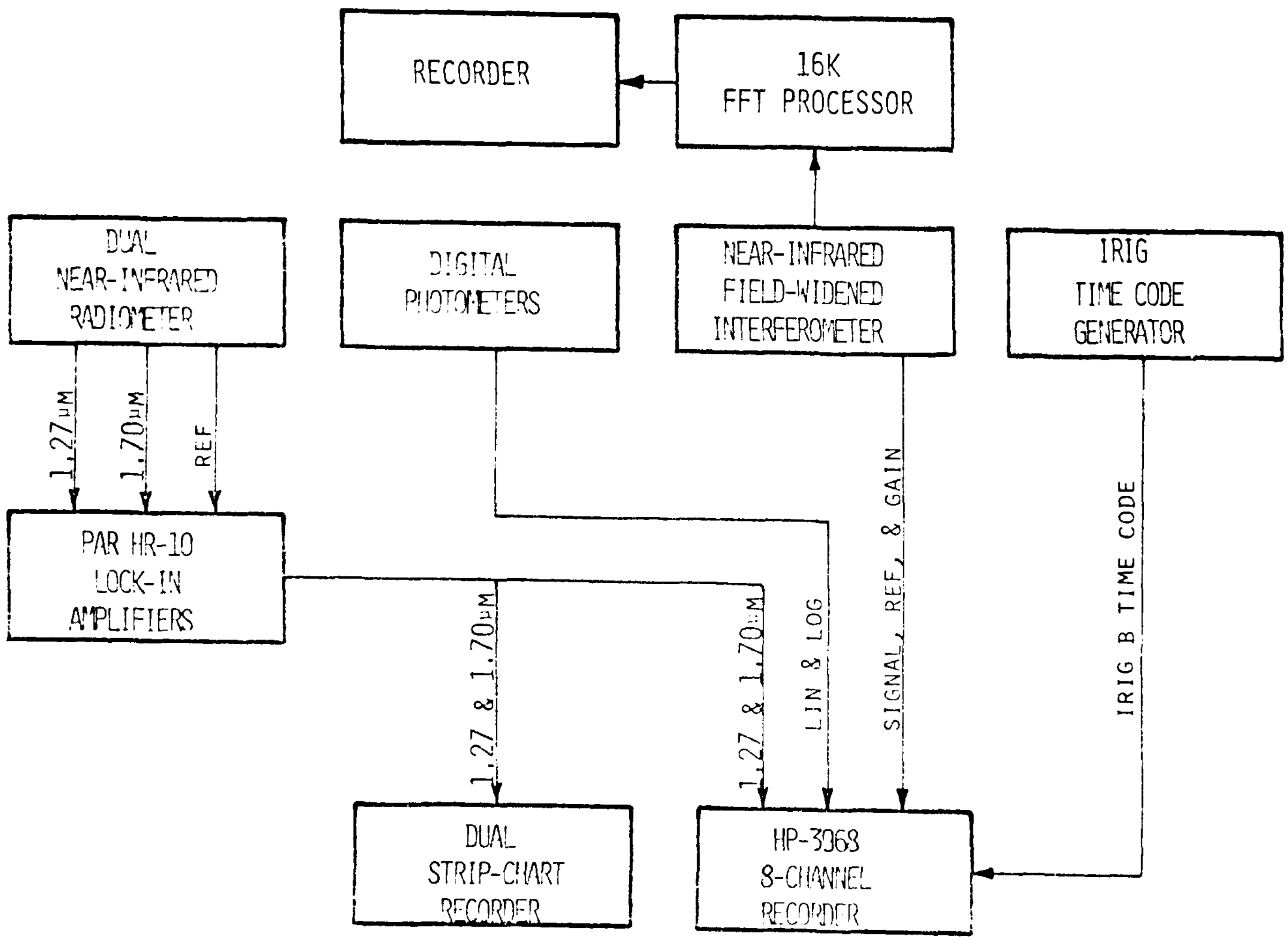

Figure 1. Block diagram of data-logging system.

the interferometer. The changing of the optical path difference to obtain an interferogram is realized by driving one of the prisms parallel with its image. The moveable mirror (prism) is mounted on an electromagnetically driven, gas-lubricated precision platform.

An intrinsic germanium photoconductor, operated at liquid-nigrogen temperature (77°K), was used as the detector in the IRFWI. This detector provides good sensitivity in the spectral region ≈1.0 - 1.6 μm and is most sensitive near 1.4 μm. The relative response of the interferometer-spectrometer was checked periodically using an internal low-brightness source which had previously been compared with a blackbody standard. Alignment of the interferometer was carried out by "peaking" the instrument response to a nearly-monochromatic source of 1.08) μm radiation. The spectral calibration was checked by means of a neon discharge tube which produced many near-IR lines of accurately known spectral positions.

The basic design of the near-infrared radiometer has been described in detail by Huppi (1976). The two-channel instrument uses a common optical chopper and a common filter wheel. The optical system consists of an f/2.5 objective lens followed by an f/0.7 field lens. In addition, the detector is "immersed" on a third lens of hemispherical shape to minimize the required detector size. The objective lens images points at "infinity" on the aperture plane which determines the instrumental field of view.

The radiometer design incorporates an optical chopper to modulate the signal. The chopper modulates the complete aperture on a duty-cycle basis of 50%. Following modulation, the signal is spectral-band limited by a bandpass interference filter. The interference filter essentially defines the relative spectral response of the instrument and limits the modulated thermal emissions which reach the detector.

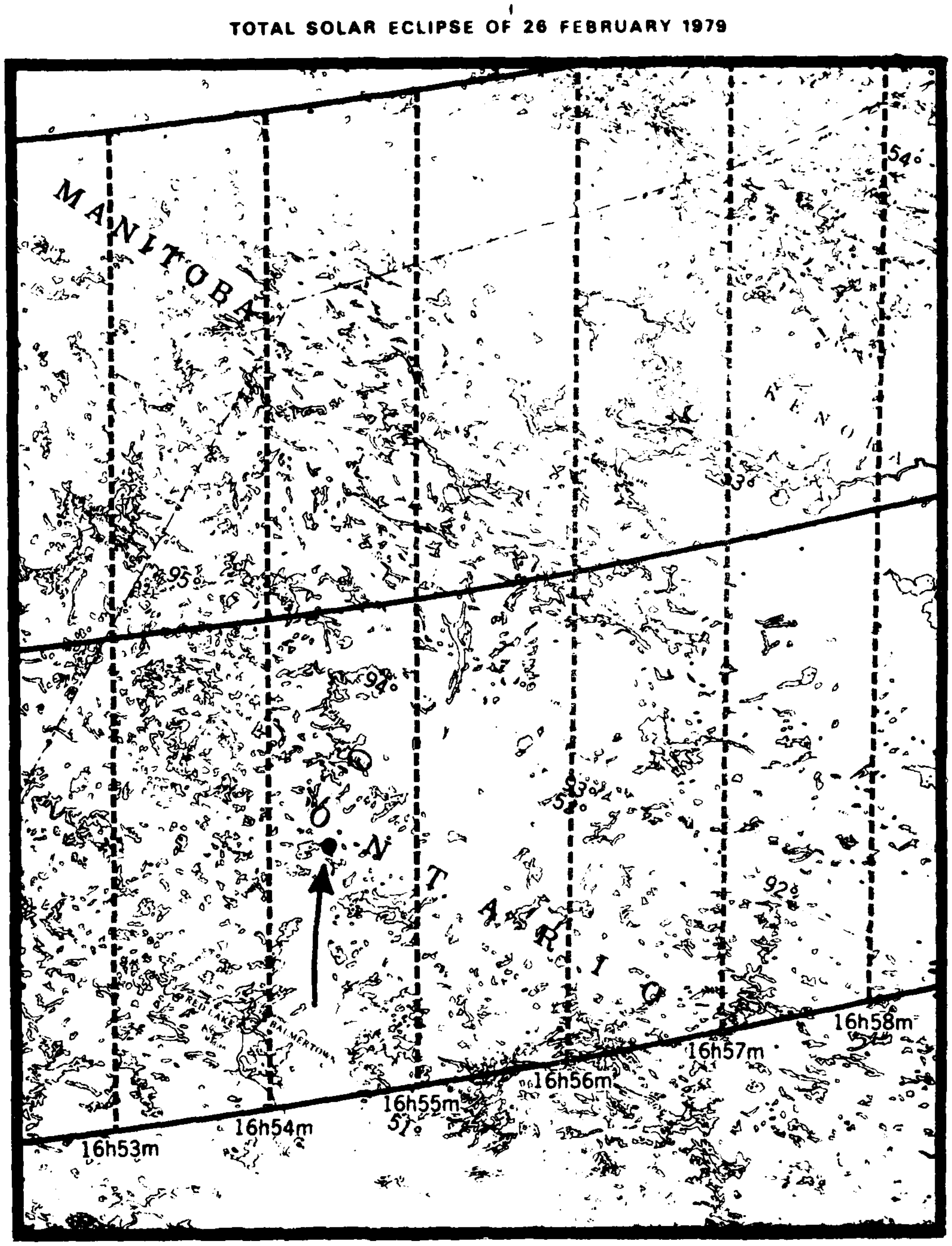

Figure 2. Section of map showing the ground track of the umbra through parts of Manitoba and Ontario in the case of the solar eclipse of 26 February 1979. The location of the remote observing site for the ground-based near-IR measurements is indicated by the open circle.

The modulated, filtered optical signal is directed to a detector where it is converted to an electrical signal. The electrical signal is then processed with a commercial lock-in amplifier. This technique provides a real time output voltage with amplitude proportional to the modulated optical energy reaching the detector.

The dual-channel radiometer used in this investigation utilized a thermoelectrically-cooled (-60°C) PbS detector in the $\lambda 1.27$ μm channel and a liquid-nitrogen-cooled (77°K) InSb detector in the $\lambda 1.70$ μm channel.

Measurements

The mobile observatory was operated from the Stormer Lake Fellowship Center, approximately 45 mi north of Red Lake, Ontario. The latitude of the observing site was 51° 34' N, the longitude about 93° 51' W, and the elevation approximately 1,500 ft above sea level. The location of the observing site in the umbra of the eclipse shadow is shown by the open circle in Figure 2. (See Fiala and Lukac, 1977.) The observing station was located approximately 46 mi from the central line.

A preliminary estimate of the duration of totality at the observing site yielded 151 sec. This was found to be in excellent accord with observations based on the temporal variation of the zenith sky brightness at a wavelength of $\lambda 5577$ Å. (Figures 3 & 4)

Good twilight-transition data were gathered on UT days 55, 56, and 58. Sky conditions were excellent on day 55, fair-to-good on day 56, and good-to-excellent on day 58. Cloudy conditions prevailed on UT day 57 through the period of the eclipse. However, the sky started to clear between 4:00 p.m. and 5:00 p.m. (local), and observing conditions were good-to-excellent through the late evening and into the night.

The various measurements indicated in Table 1 were made during the

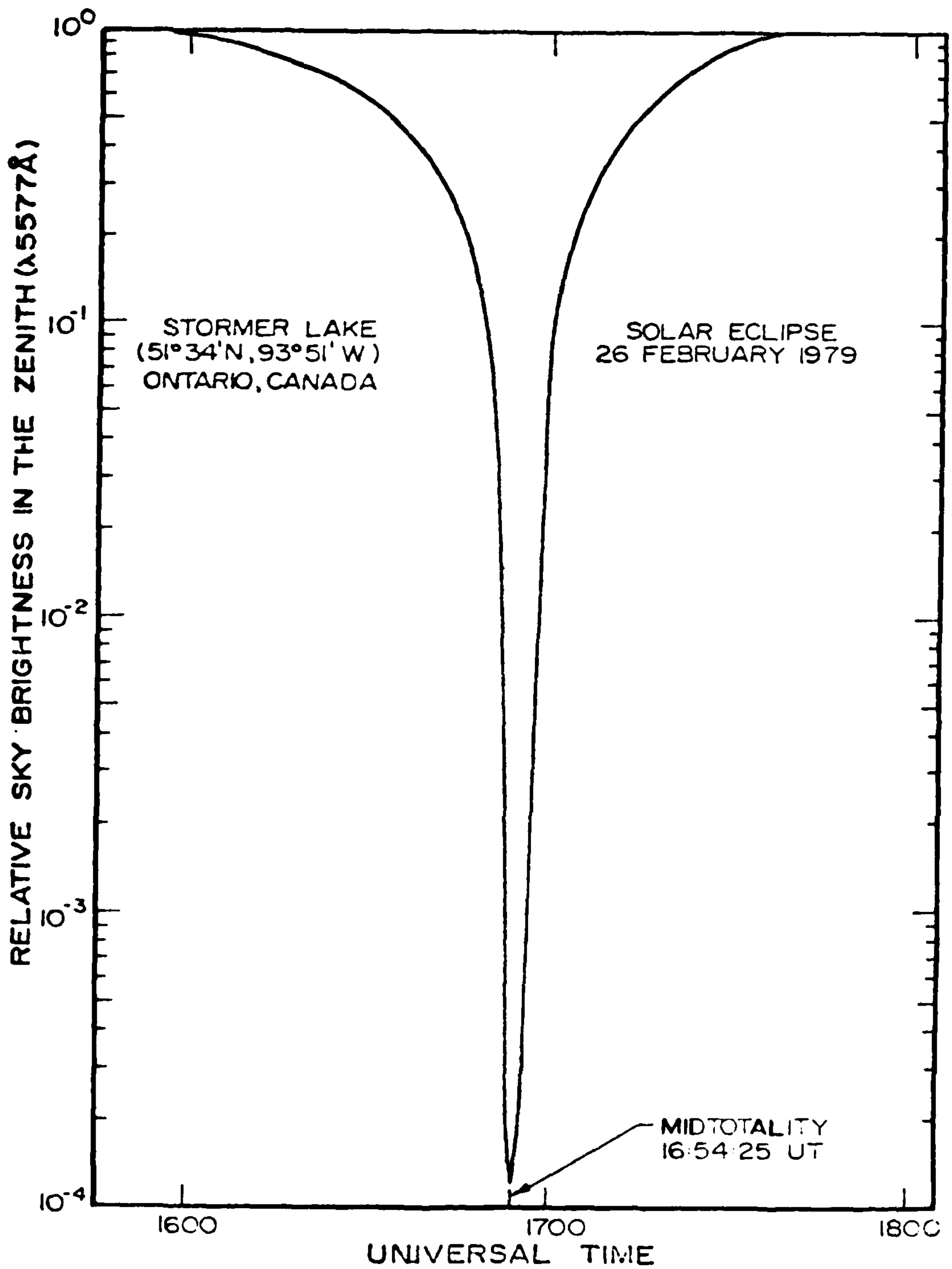

Figure 3. Zenith sky brightness (relative) of λ5577Å vs. time ... solar eclipse of 2 February 1979.

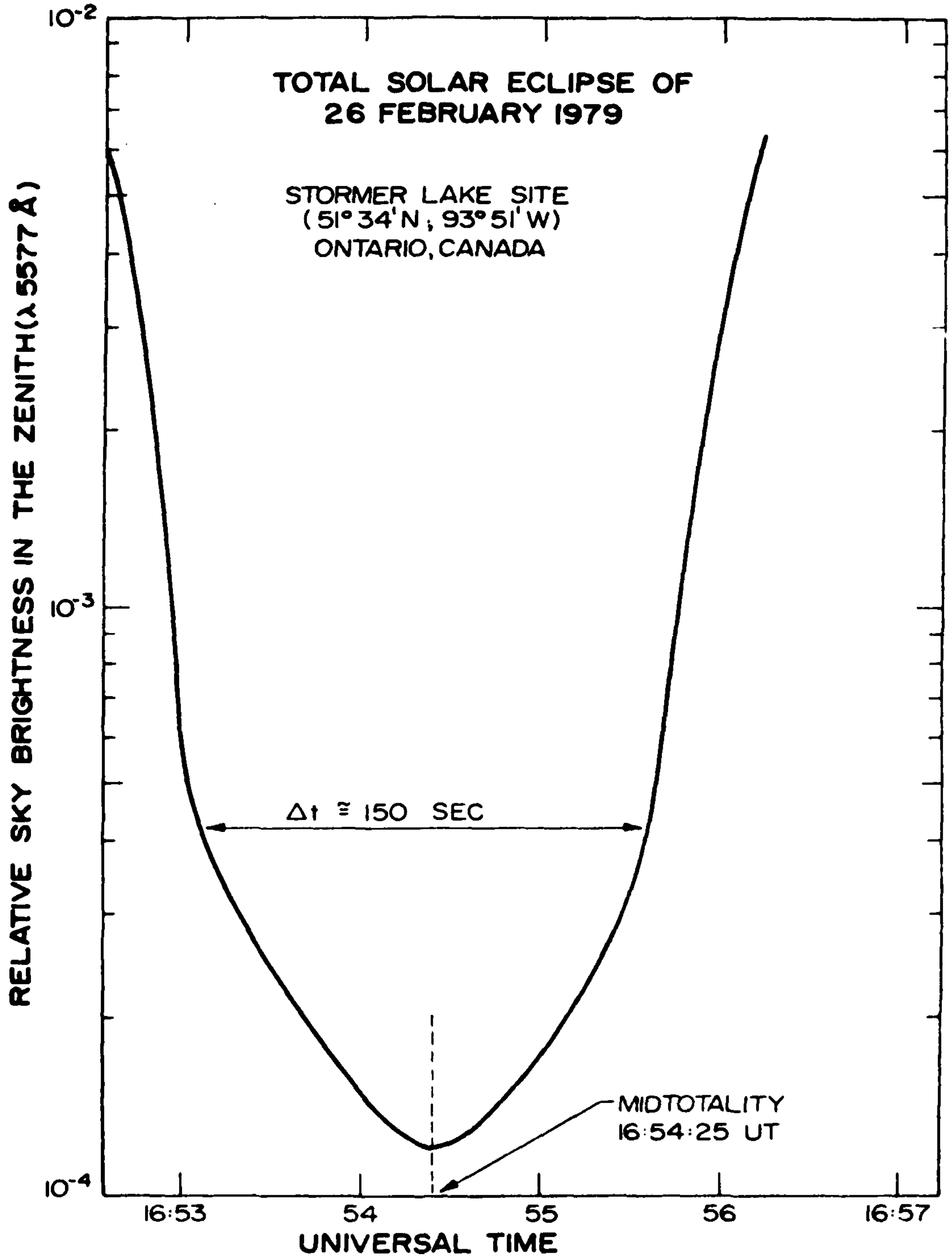

Figure 4. Expansion of Figure 2 around totality.

observing periods on the aforementioned days. The data were recorded on magnetic tape and/or strip charts, as appropriate. Selected interferograms from the IRFWI were transformed on site with a Unigon Model 4516 FFT processor. This unit yielded a 16K transform, which permitted a satisfactory evaluation of instrument performance.

PRINCIPAL RESULTS

Eclipse-Related Measurements

The zenith sky brightness at λ5577Å was monitored during the eclipse with a digital photometer (Table 1). A special "neutral density" filter was prepared in the field to produce a pre-eclipse signal near the upper limit of the instrumental dynamic range. The dynamic range of the instrument with an uncooled detector was slightly greater than $10^4/1$, which proved adequate for the range of light levels during the eclipse. The sky-brightness data are displayed in Figures 3 & 4.

The IRFWI measurements at totality are displayed in Figure 5. The time-resolved sequence of spectra in the figure clearly reveal airglow features superposed on a background of scattered radiation. The prominent airglow features which have been identified in the spectra of Figure 5 are summarized in Table 2. In addition to the features given in Table 2, some rotational lines belonging to the OH Meinel (7,4) transitions appear weakly in the spectra.

The spectral "voids" (or near voids) which occur in the regions near 7250 cm^{-1} and 8800 cm^{-1} result from water-vapor absorption bands. The rather "noisy appearance" of the data near these absorption regions reflects the structure of the absorption in the wings of the bands. The absorption at the centers of most of the individual lines is incomplete in the wings of the band. As a consequence, large variations in the effective transmission

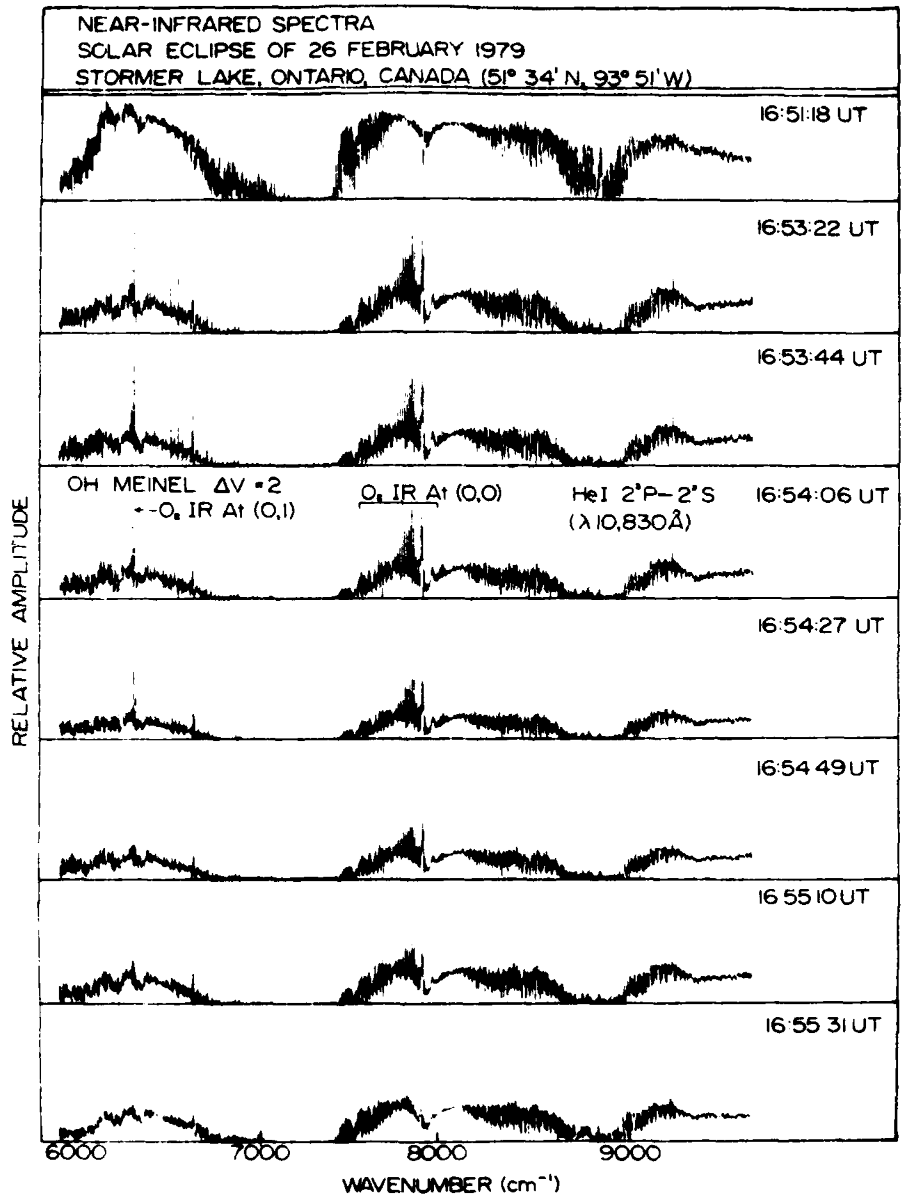

Figure 5. Near-infrared residual airglow spectra from measurements at totality.

TABLE 2. Summary of prominent airglow features identified in the residual airglow spectra of Figure 4. (Eclipse of 2/26/79).

approximate spectral position (cm^{-1})	identification	comments
6,000 - 7,000	various rotational lines of the OH Meinel $\Delta V = 2$ sequence	intensity appears to increase slightly to midtotality and then to decrease
6,330 region	O_2 IR atmospheric (0,1) transition	intensity decreases during totality both absolutely and relative to OH M emissions
7,890 region	O_2 IR atmospheric (0,0) transition	intensity decreases during totality
9,235	HeI $2^3P \rightarrow 2^3S$	temporal variation appears to "track" scatter, as expected

coefficient occur over spectral intervals small compared to the instrumental width.

The approximate universal time corresponding to the beginning of each scan is given near the right-hand margin of the panel. It should be noted that the observing time per interferogram was between 21 and 22 sec. The approximate duration of totality at the observing site was 150 sec (Figures 3 & 4). Hence, as shown in the figure, roughly seven scans were recorded during totality. The top panel provides a reference spectrum taken about two minutes before totality. (The instrumental sensitivity was greatly reduced in this scan, as compared to the other scans of Figure 5 for which the instrumental sensitivity was constant.)

The quantitative interpretation of these first-of-a-kind residual dayglow spectra must be approached with caution in view of the overcast conditions during the measurements. Checks of the zenith sky brightness prior to first contact revealed only very slight changes ($\lesssim 5\%$) in time intervals of a few minutes. Hence, the cloud cover seemed rather stable, and the temporal variations in the spectra of Figure 5 are deemed representative of actual changes in the residual dayglow during totality.

Some general observations relating to the temporal variations in the spectra can be made with reasonable confidence.

1. The intensity of the HeI $\lambda 1.083$ μm emission exhibited a minimum near midtotality with values at second and third contacts significantly greater (factors in the range 2-4). The temporal variation appears to be consistent with scattering of sunlight by $He(2^3S)$ as the dominant source.

2. The intensities of the O_2 infrared atmospheric bands at $\lambda 1.27$ μm and $\lambda 1.58$ μm monotonically decrease throughout totality. This observation is in accord with the predictions of the model of Thomas and Bowman (1974) provided the column emission rate at totality is dominated by contributions from altitudes ≈ 70 km.

3. The O_2 emission at $\lambda 1.58$ µm decreases in intensity relative to the Q_1 line of the OH Meinel (4,2) band during totality. This observation is in agreement with the predictions of current photochemical models.

4. The intensities of the OH Meinel emissions in the $\Delta v = 2$ sequence appear to decrease by $\sim$ 30% during totality. The model of Thomas and Bowman (1974) predicts increases in OH at all heights between first contact and the middle of the eclipse. Hence, this observation appears to disagree with the model, and additional effort appears warrented.

Twilight-Transition/Nightglow Measurements

Twilight-transition and nightglow data were obtained on UT days 55, 56, and 58, as previously noted. Radiometric data for UT days 55 and 58 are compared in Figure 6. The two-channel radiometer has previously been described. The temporal variations of the $\lambda 1.27$ µm [O_2 IR At (0,0)] and $\lambda 1.70$ µm [OH Meinel Δv=2] emissions were similar on the two evenings. However, both of the emission levels were significantly higher on UT day 55.

Spectral data in the 7800 cm^{-1} region from the evening of 27 February 1979 are shown in Figure 7. The presence of the OI emission at about 7596 cm^{-1} ($4s\,^3S \rightarrow 3p\,^3P$) signals the occurrence of particle precipitation early in the evening on the day of the eclipse. However, the temporal variation of the $\lambda 1.27$ µm radiometric signal (Figure 6) during the evening suggests little if any perturbation on the typical twilight transition depicted by the date of 24 February 1979. Particle precipitation was essentially undectectable during the evening on 2/24/79.

The O_2 IR At (0,0) twilight measurements from the evening of the eclipse are compared in Figure 8 with similar measurements by Evans et al. (1969) and by Reese (1976), the latter measurements differing in both latitude and season. It is seen from the figure that the three data sets are very similar. A quantitative comparison of these plus other $\lambda 1.27$ µm twilight measurements is presented in Table 3. The observed change in the O_2 IR At (0,0) column emission rate from a solar depression angle (β) of 6° to 10° is com-

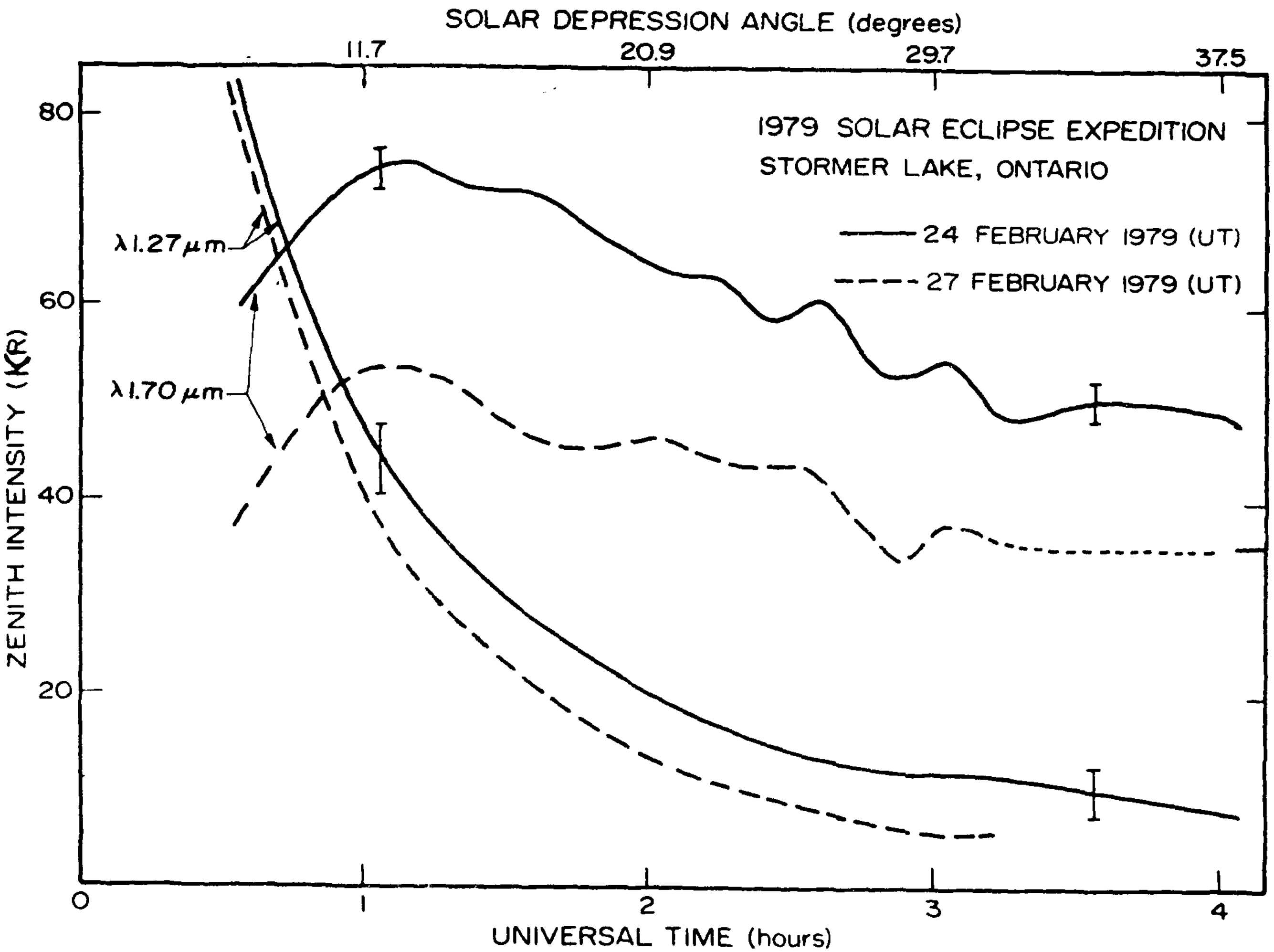

Figure 6. Twilight transitions for the O_2 λ1.27-μm emission and OH Meinel Δv=2 emissions (Solid Curves: 24 February 1979; Dashed Curves 26 February 1979).

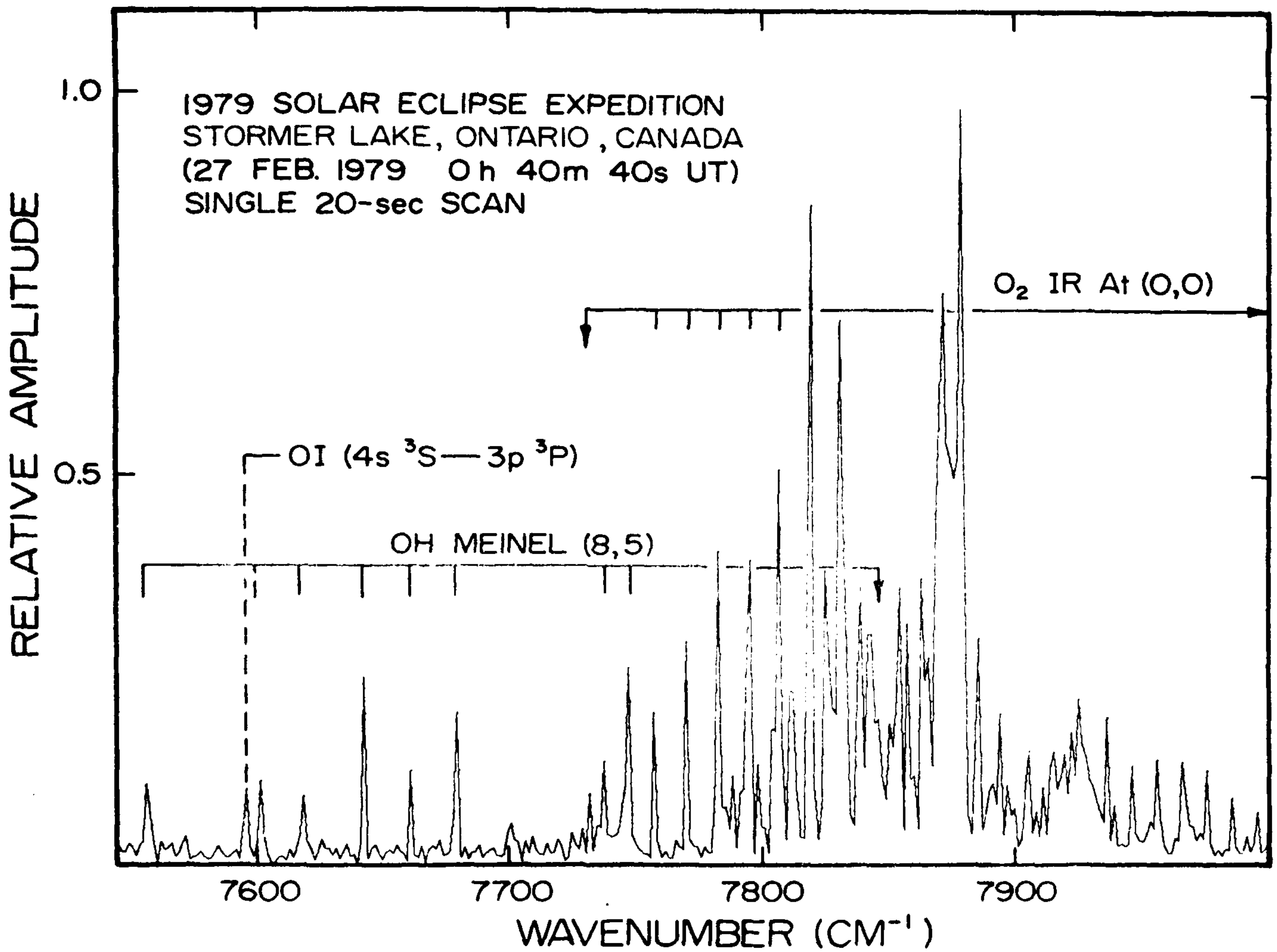

Figure 7. Interferometer scan for the 7800-cm^{-1} region on the evening of 27 February 1979 UT.

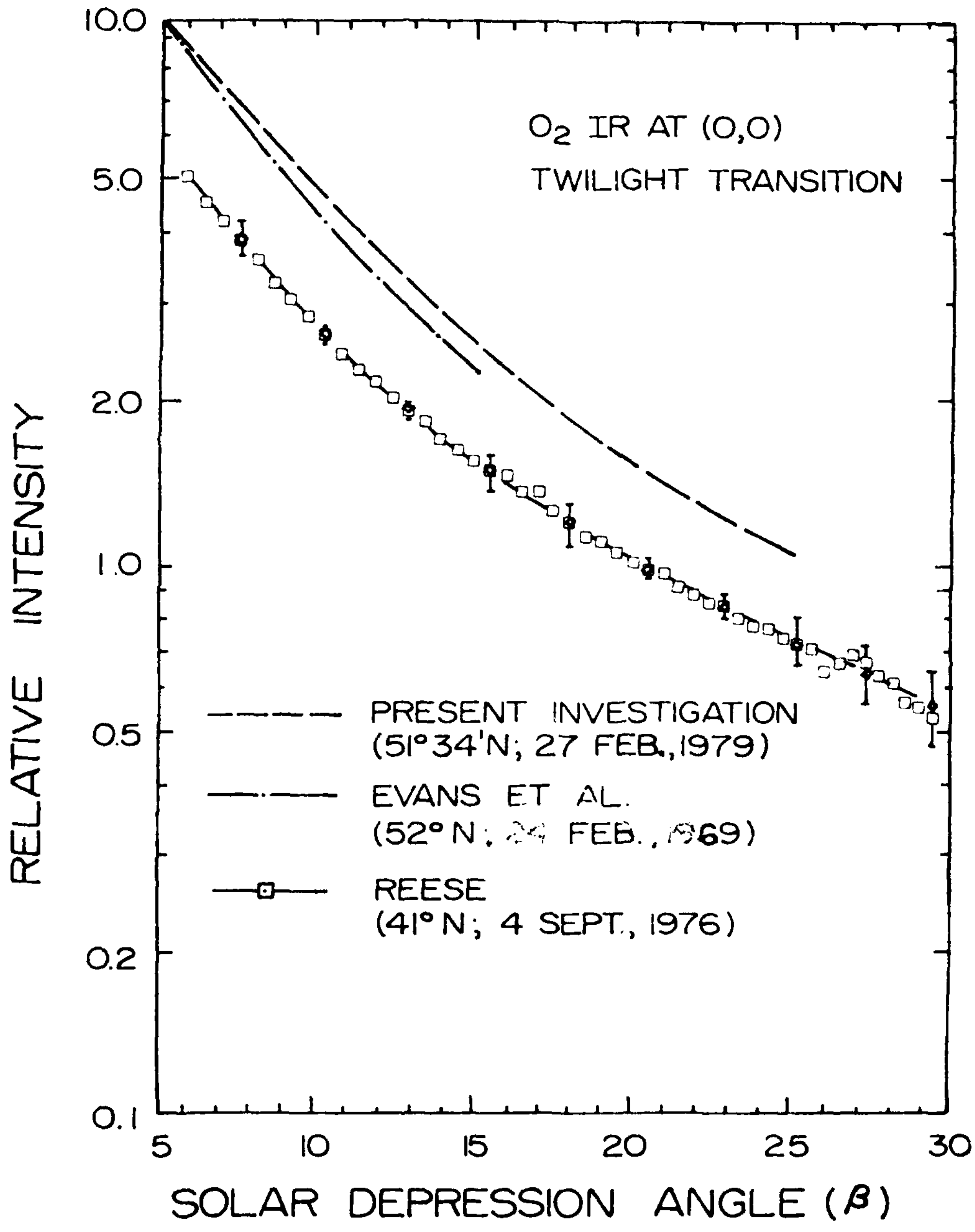

Figure 8. Comparison of twilight-transition measurements for the O_2 feature at $\lambda 1.27$ μm.

Table 3. Comparison of Observed Changes O_2 $(a^1\Delta_g)$ Concentration from $\beta = 6°$ to $10°$.

REFERENCE	LATITIDE	DATE	PERCENT CHANGE
Gattinger (1968)	45°N	Dec-Jan, 1966	45
Gattinger (1968)	45°N	May 30, 1967	70
Evans et al. (1969)	52°N	Feb 24, 1969	44
Pick et al. (1971)	58°N	Aug, 1968	62
Reese (1976)	41°N	Aug-Sep, 1976	47
Present Result	52°N	Feb, 1979	42

pared for the various observation. The weight of evidence points toward a percent change of roughly 45%, essentially independent of latitude and season. It does not appear that the temporal behavior of the twilight transition data on 2/27/79 were significantly perturbed by the eclipse; however, the magnitude of the emissions may have been affected.

The apparent O_2 $\lambda 1.27$ μm nightglow emission levels were between 5 and 10 kR during the observing period, corresponding to $\sim$100 kR in the zenith after correcting for atmospheric extinction (self absorption). These levels are commensurate with the measurements of Evans et al. (1969) and other earlier investigators. The nightglow levels for the O_2 $\lambda 1.27$-μm emission and the OH M $\Delta v = 2$ emissions in the 1.7-μm region are distinctly lower on the evening of 2/27/79 than on the evening of 2/24/79, although the temporal variations were very similar on the two evenings.

The twilight-transition measurements with the IRFWI can be used to infer OH Meinel rotational temperatures. The line intensity distribution in selected OH Meinel bands provides a convenient "index" of the effective rotational temperature for the OH Meinel emissions.

High quality data (low noise and high relative accuracy) are required for reliable estimates of the rotational temperates. Recently, software routines have been implemented at USU to provide near-optimum reduction of the raw data from the interferometer. These routines permit the co-addition of interferometer scans to yield a high S/N ratio; phrase correction, apodization, and interpolation are included in the routines.

A sample of the high quality IRFWI results is shown in Figure 9. The results displayed in the figure were obtained by co-adding approximately 150 interferometer scans taken during the evening on 2/27/79. The observing time for each scan was approximately 20s; hence, the results in the figure

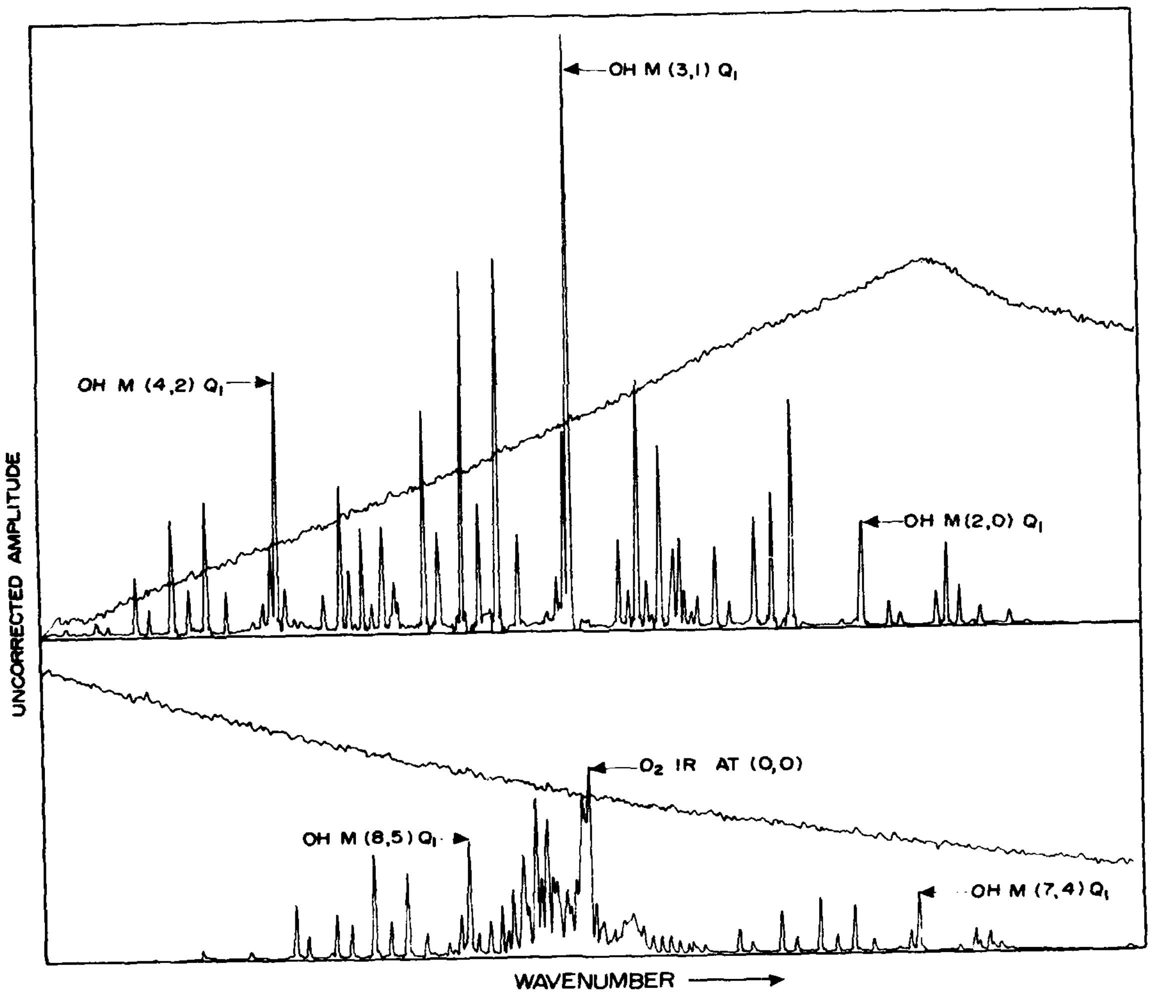

Figure 9. Near IR spectra reflecting approximately 150 scans of the interferometer.

correspond to roughly an hour of observing time. The strong water-vapor absorption in the region between the OH Meinel (2,0) and (8,5) bands provides a quasi-void for estimating the noise level in the spectra. The very high S/N ratio in the spectra is apparent in this region. Estimates of the rotational temperature have yielded (200 ± 20)°K, in good agreement with the AFGL falling-sphere measurements in the 85-km region on the same day.

Auroral Measurements

Auroral measurements were not deemed an objective for the mission. However, the general period of the solar eclipse was characterized by considerable auroral activity, and measurements during the late evening and night on 27 February 1979 (local) yielded unique and rather interesting near-infrared auroral spectra, in particular, high-quality data were acquired for the [NI] 3F emission near 1.04 μm.

A sample of early evening (sunlit) auroral spectra is shown in the upper panel of Figure 10, whereas a typical night-time spectrum is displayed in the lower panel. An expanded plot of the λ1.04-μm region is shown in Figure 11. In comparing the two scans, it is apparent that the intensity ratio I [NI 3F]/ I [N_2+M(0,0)] is significantly larger in the sun-lit spectra. The ratio inferred from the spectra is consistent with a yield factor of ∿ 0.03 [NI] 3F $^2P \rightarrow ^2D_{3/2,5/2}$ emissions in the aurora. These transitions are fully resolved, as is clear from the figure, and the ratio of "line" intensities is in reasonable agreement with the theoretical (statistical equilibrium) value of 1.43.

Comparison with Rocket-based Measurements

The cloud cover during totality prevented a comparison of the ground-based near-IR measurements with the rocket-based measurements.

SUMMARY AND CONCLUSIONS

Near-IR spectrometric (0.8-1.65 μm) and radometric (λ1.27 μm, λ1.70 μm) measurement of the terrestrial airglow have been made in conjunction with the

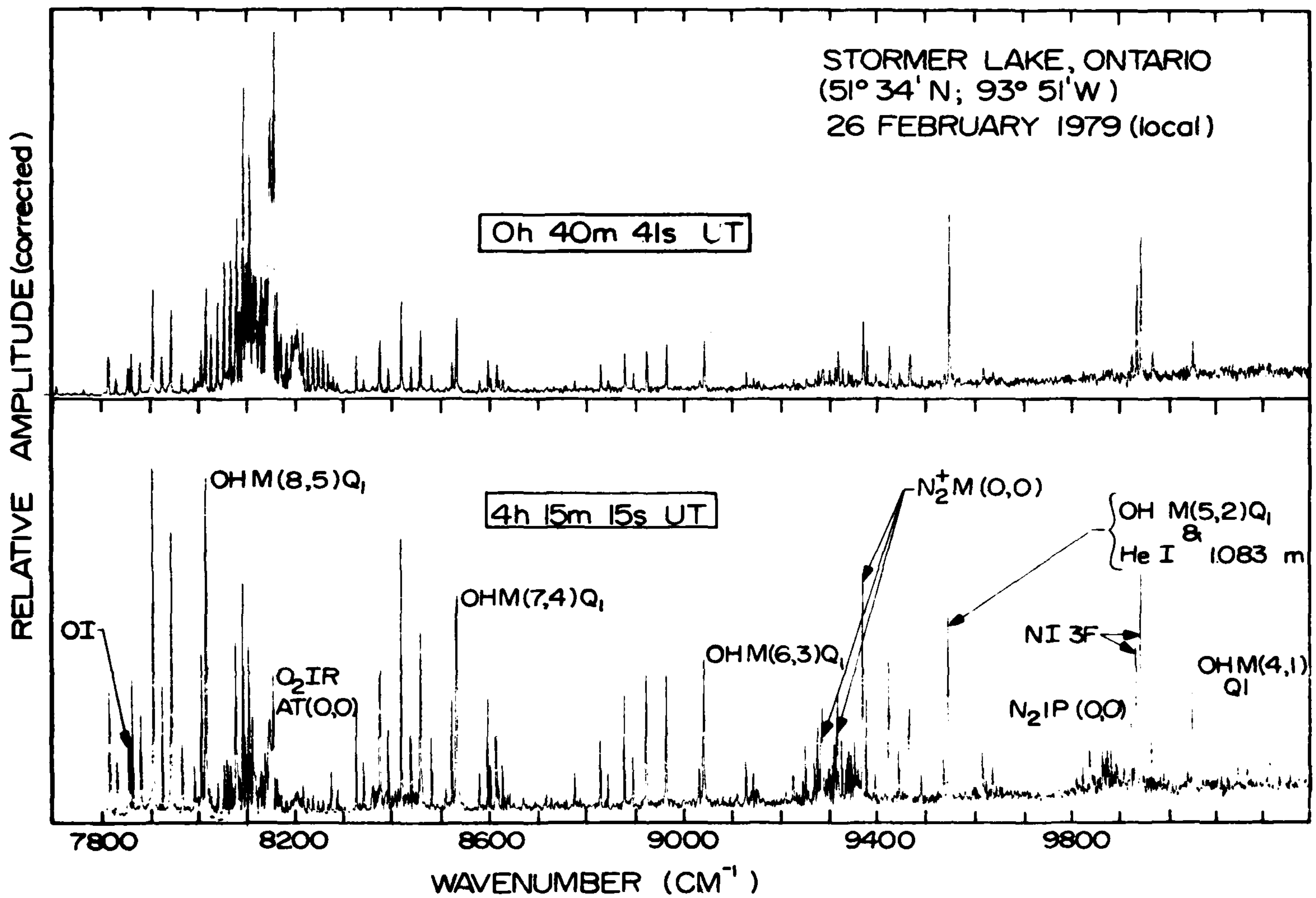

Figure 10. Comparison of auroral (plus airglow) spectra from the early evening period (upper panel) with similar measurements taken later in the evening (lower panel) on 2/27/79 (UT).

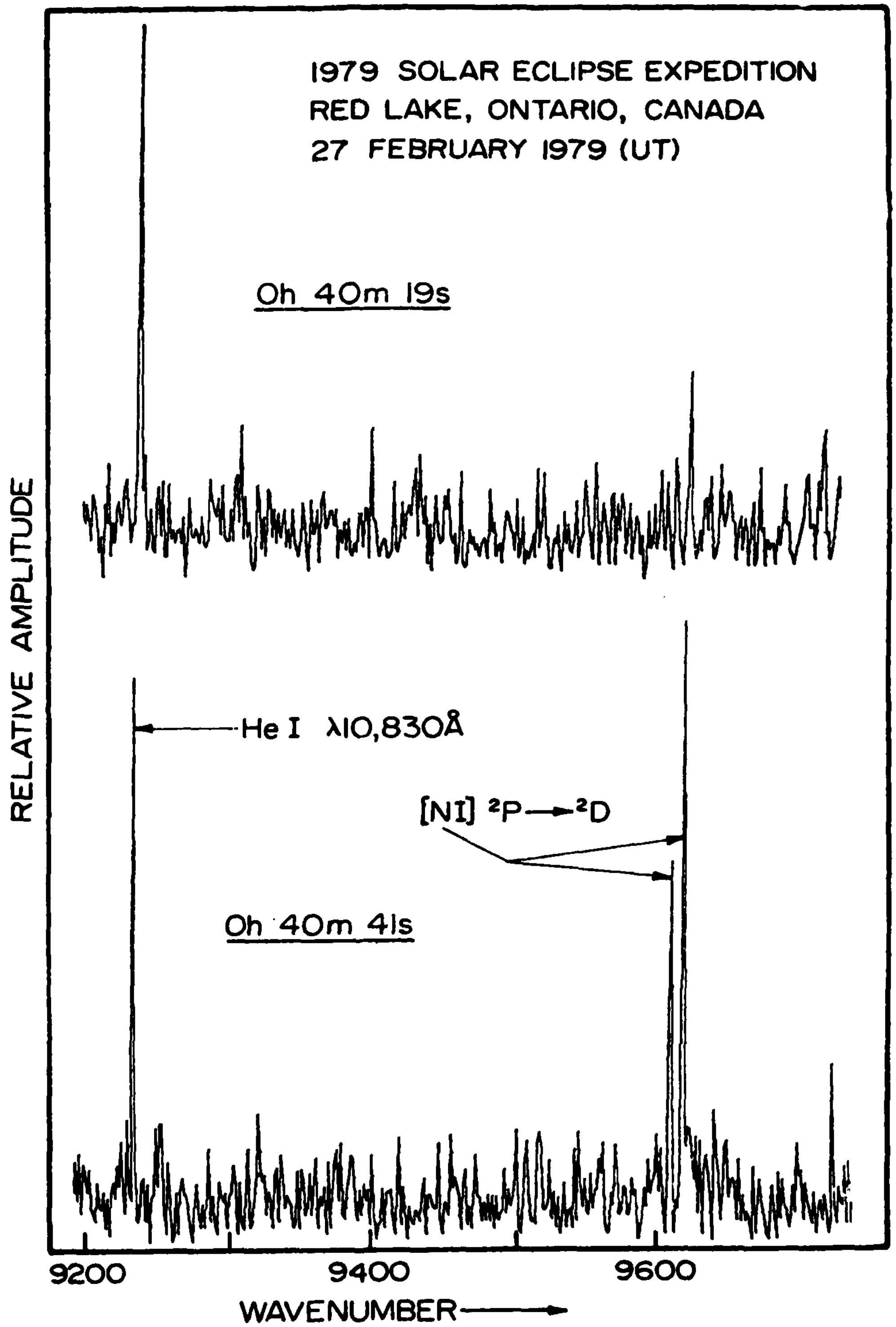

Figure 11. Expanded plot in the λ1.04-μm region of IRFWI results obtained in the early evening on 2/27/79 (UT).

total solar eclipse of 26 February 1979. Twilight-transition and nightglow data were acquired on 2/23, 2/24, and 2/26. The temporal variations of the dominant features were similar on the three nights, but relatively large differences in the emission levels were apparent, with airglow intensities significantly lower on 2/26.

First-of-a-kind time-resolved spectra of the near-IR residual dayglow were made with a spectral resolution of < 3 cm^{-1} and a temporal resolution $\sim$20 sec. With the possible exception of the OH Meinel features, the features behaved as predicted from photochemical models of the mesosphere and lower thermosphere.

It was aurorally active in the late evening and night on the day of the eclipse. Sun-lit auroral spectra during the twilight have yielded a value of $\sim$0.03 [NI] 3F photons per N_2^+ ion. The [NI] 3F emissions exhibited striking changes with respect to the other auroral features, presumably due to changes in the auroral altitude.

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APPENDIX A

List of Contributors

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K. Briggs	

APPENDIX B

Presentations at Meetings/Manuscripts in Preparation

Presentations at Meetings

Pendleton, W. R., Jr., D. J. Baker, and A. J. Steed, *Residual Dayglow and Twilight-Glow Measurements in Conjunction with the 26 February 1979 Solar Eclipse*, paper presented at the Spring Meeting of The American Geophysical Union, Toronto, Canada, 22 May 1980. Abstract published in *EOS, Trans. Am. Geophys. Union, 61*, 17, April 1980.

Pendleton, W. R., Jr., presentation at 1979 Solar Eclipse Workshop, convened at New Mexico State University on 26-27 September 1979.

Manuscripts in Preparation

Pendleton, W. R., Jr., D. J. Baker, and A. J. Steed, Temporal Variation of Residual Dayglow Features During the Total Phase of the 26 February 1979 Eclipse, (to be submitted to either *Applied Optics* or *Journal of the Optical Society of America*).

Pendleton, W. R., Jr., D. J. Baker, and A. J. Steed, Spectrally Resolved [NI] 3F Emissions in Sunlit and Normal Aurora, (to be submitted to *Journal of Geophysical Research* or *Geophysical Research Letters*).

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